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6. AUTHOR(S)
Dr Paul M. Harvey

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Univ of Texas
Department of Astronomy
Austin, TX 78712

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The research carried out under this grant consisted of two major parts as well as one exploratory program. The first phase of the research involved the completion of hardware development of a two-dimensional infrared camera system based on a 62 X 58 infrared array detector. The second phase involved an observational program to study the infrared brightness and colors of infrared galaxies particularily those in interacting systems. The final part of the program was a small exploratory inquiry into the feasibility of very high angular resolution imaging via speckle interferometry in the infrared.

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FINAL TECHNICAL REPORT

GRANT AFOSR 86-0083

I. INTRODUCTION

The research carried out under this grant consisted of two major parts as well as one exploratory program. The first phase of the research involved the completion of the hardware development of a two-dimensional infrared camera system based on a 62 x 58 infrared array detector. The second phase involved an observational program to study the infrared brightness and colors of infrared galaxies, particularily those in interacting systems. The final part of the program was a small exploratory inquiry into the feasibility of very high angular resolution imaging via speckle interferometry in the infrared.

II. HARDWARE DEVELOPMENT

Most of the hardware components of the infrared camera system were already in hand at the start of this program, but a large amount of integration, testing, and software development was required to enable a working instrument to be placed at the telescope. All this work was supported by this grant. The final camera system enjoyed the following properties.

1. A multi-position filter wheel with space for a variety of broad band and narrow band filters was used, with additional space for a circular variable filter wheel.
2. A multi-position lens slide enabled the use of the array with several different focal plane scales and its use at telescopes with f/ratios between f/15 and f/45. This was extremely important for its use on five different telescopes in Texas, Hawaii, and Australia.
3. The detector substrate could be maintained at any temperature between 4K and 77K, allowing us to optimize tradeoffs between dark current and quantum efficiency for various observing modes.

4. A completely self-contained data acquisition and analysis system based on DEC Microvax computer and attached Analogic array processor proved invaluable for real time image evaluation while observing and rapid data reduction during the daytime following a night's observing.

5. An optical design was employed which allowed a variety of types of observations to be made with no significant cryostat changes. For example, the speckle interferometry program described later, as well as some recent polarimetric imaging tests were all done with a minimal amount of modification to the external guider box, and no internal dewar changes.

III. SOFTWARE DEVELOPMENT

The software development has been an on-going task since the array detector was first placed in its cryostat. The main accomplishments in this area are:

1. There is a truly real time display of the detector output with a frame rate faster than 1 Hz, allowing guiding, focussing, and other simple but necessary observing operations to be accomplished quickly and easily, even in the middle of the night at 14,000 feet altitude.

2. We have a suite of quick-look data display algorithms as well as final data reduction algorithms written in an extremely versatile commercial imaging "language", IDL. These programs make it possible for the observer to determine quickly if the array is operating properly and to process the data after an observing run with a minimum effort.

IV. SCIENTIFIC RESULTS

The most complete scientific results are described in detail in the attached reprints and preprints of papers for scientific journals and from meeting presentations. The prime goal of the research with this camera was to study the distribution of near-infrared radiation from infrared galaxies with an emphasis on those in interacting systems. Our first publication was on "The Genesis of the Ring Galaxy Arp 144" where we showed that this system could not be the result of a collision between an intergalactic H I cloud and a

galaxy, but must be the result of a collision between two roughly equal mass galaxies. A second paper from this research program has just been submitted to the *Astrophysical Journal* on "An Infrared Jet in Centaurus A: A Link to Extranuclear Activity in Distant Radio Galaxies". The infrared colors of the jet in this galaxy as determined with our imaging show that it cannot be attributed to synchrotron emission from a beam of relativistic electrons, unlike many other active galactic nuclei. An AAS meeting presentation of our results on the interacting :"Cartwheel Galaxy" show that in this interacting system, the visual rings are extremely faint in the infrared suggesting that the current induced star formation must be a strong and recent event which has not yet built up a large population of older stars from a previous "starburst". In addition to these already published results, we also have a number of images of galaxies yet to be analyzed. We expect these data to be coming out over the next couple of years.

We have also been conducting two secondary research programs with this infrared camera in order to fully understand the limitations of the detector and its ultimate capabilities. The first of these programs, as mentioned above, is our work on infrared, two-dimensional, speckle interfeormetry. This program has demonstrated the ability to obtain true, diffraction-limited data out to the spatial frequency limit imposed by the telescope aperture for telescopes as large as the 3.9 meter Anglo-Australian Telescope, and, with sufficient integration time of several hours, for stars fainter than 7.0 mag at 2.2 microns. Because of the scientific drivers and practical limitations on availability of sources, this program has been aimed at studying low mass protostellar objects in regions of star formation in our galaxy. In addition to this high spatial resolution program we have also obtained a number of images of the same star forming regions at lower spatial resolution to study the complementary properties of speckle and wide field imaging of the same regions of the sky. We expect to be publishing some results of this program in the coming year.

V. FUTURE WORK

Our future work will depend on the level and source of any further funding which we can obtain for this project. In general, though, our work will be driven by the upcoming acquisition of a 128 x 128 HgCdTe array funded by NSF and UT this year, and a 256 x 256 array probably in the following year. These arrays will operate between 1 and 2.5 microns with a factor of 10 lower read noise than the existing array. We expect, therefore, to use the existing array only for the high background observations longward of 2.5 microns where the system noise will be dominated by background rather than read noise. Our program of imaging of interacting galaxies will be greatly enhanced by the acquisition of these new arrays since they will be much more sensitive at the J and H wavebands than our existing system, and they will cover 5 to 20 times the area in one telesope setting. We also plan to perform speckle interferometric observations with these new arrays since that program was strongly limited by read-out noise and the number of pixels.